for improved clinical assessment and convenient visual display of ischemia at rest and with stress echo.

939-114 Insights From Three-Dimensional Echocardiography Into the Mechanism of Functional Mitral Regurgitation: Direct In Vivo Demonstration of Leaflet Tethering Geometry

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Recent advances in three-dimensional (3D) echocardiography can allow us to address uniquely 3D scientific questions, such as the mechanism of functional mitral regurgitation (MR) in LV dysfunction. Competing hypotheses include global LV dysfunction with inadequate leaflet closing force vs geometric distortion of the mitral apparatus by LV dilatation, restricting leaflet closure. We addressed these possibilities by infusing esmolol and phenylephrine in 6 open-chest dogs to induce LV dysfunction, first limiting LV expansion by increasing pericardial restraint and then opening the pericardium. The 3D relations of the papillary muscle (PM) tips and valve were reconstructed from midsystolic rotated apical echo views, and MR stroke volume (SV) calculated as LV-forward aortic (flowmeter) SV. *Results:* 1) With pericardial restraint, despite EF = 17 ± 5%, only trace MR developed with mildly increased LV end-systolic volume. 2) With open pericardium, moderate MR developed as the LV dilated. 3) MR SV significantly correlated with the tethering distance from the PMs to the anterior annulus, especially posterior and medio-lateral PM shifts, as well as annular area ($p < 0.0005$). By multiple regression, the PM-to-annulus distance was the only significant independent predictor ($r^2 = 0.81$, $p = 4 \times 10^{-7}$). *Conclusions:* LV dysfunction without dilatation fails to produce important MR. Functional MR relates strongly to changes in the 3D geometry of the mitral valve attachments at the PM and annular levels, with practical implications for approaches that would restore a more favorable configuration.

939-115 Left Ventricular Volumes Measured from Intracardiac Echocardiography Images Using Novel Geometric Methods, Automated Border Detection and 3D Reconstruction

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Intracardiac Echocardiography (ICE) optimizes endocardial signals which facilitates quantitative assessment of regional wall motion, wall thickness and Left Ventricular (LV) volume measurements. Our purposes were first to determine LV volumes from ICE images by (a) the standard Simpson's rule method b) new geometric methods and c) a new automated border detection method for 3D reconstruction (3DR), and second, to compare calculated to displacement volumes. A 10 F, 10 MHz intracardiac ultrasound transducer was placed in the LV of 8 excised swine hearts suspended in a saline bath. Short axis views (SAX) of LV were obtained at 0.5 cm increments from apex to the mitral annulus. The four reconstruction models used were 1) Cylindrical discs 2) Trapezoidal discs 3) Ellipsoidal discs and 4) 3DR. The 3DR method generates fully automated computer determined endocardial and epicardial borders. LV volumes are calculated automatically from a shape-based interpolation of all cross sectional areas from the apex to the mitral valve annulus. The computed volumes from all methods were compared with the true displacement volumes measured. *Results:* The mean and standard deviation of the errors (displacement – calculated volume in cc) were 1) 1.28 ± 1.01, 2) 1.22 ± 1.14, 3) 1.18 ± 1.08, 4) 1.21 ± 1.11, respectively. True volume was significantly correlated with the ellipsoidal method, $y = 0.85x + 1.48$, $r = 0.93$, and the 3DR method, $y = 0.73x + 2.6$, $r = 0.93$. LV cross-sectional areas determined manually were highly correlated with automated computer defined areas, $y = 0.98–0.01$, $r = 0.97$. *Conclusion:* Images from an ICE catheter in the LV can be analysed by a precise 3DR method, which generates reliable automated cross-sectional areas of the LV endocardial surface, and provides accurate analysis of LV volumes. The new ellipsoidal and trapezoidal disc methods are as accurate as the traditional cylindrical disc methods.

939-116 Intracardiac Echocardiography Can Quantitatively Image the Left Ventricle from a Right Ventricular Transducer Position

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The left ventricle (LV) of canines and humans has been studied with intracardiac echocardiography (ICE). Usually ICE is performed with the ultrasound catheter in the chamber being studied because of limited depth of field. The availability of lower frequency ultrasound catheters may allow LV imaging from the RV – a more clinically attractive approach. Our purpose was to demonstrate that an ICE catheter placed into the RV can quantitatively image the LV and monitor changes in LV function. A 10 F, 10 MHz ultrasound catheter was placed into the RV of 10 closed chest swine via the right internal jugular vein. We evaluated global and regional LV response to dobutamine and balloon catheter coronary occlusion. Baseline and intervention LV cross sectional end diastolic and end systolic areas, and % of LV circumference with a wall motion abnormality (% Circ WMA) were measured. LV cross sectional area ejection fraction (Area EF) was calculated. Transthoracic echocardiography (TTE) was used as a comparison. *Results:*

Area EF	Baseline	Dobutamine	Coronary occlusion	% Circ WMA
ICE	0.73	0.89	0.48*	23
(SD)	(0.05)	(0.05)	(0.07)	(3)
TTE	0.80	0.91	0.53*	22
(SD)	(0.03)	(0.06)	(0.06)	(2)

*$p < 0.05$, vs baseline

There were no significant differences between ICE and TTE measurements. Thus, the LV can be quantitatively and accurately imaged from the RV using ICE in swine. ICE warrants clinical evaluation as a method for monitoring LV function in the catheterization lab and CCU.

939-117 Determination of Left Ventricular Aneurysm Surface Area by Dynamic Three-dimensional Echocardiography

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The Quantification of left ventricular aneurysm surface area (ASA), as a region of dysfunction, and total endocardial surface area (TESA) by two-dimensional echocardiography using geometrical algorithms is inaccurate, particularly in asymmetric left ventricles.

In order to detect the percentage of left ventricular dysfunction tomographic three-dimensional (3-D) echocardiographic (3-DE) quantification of ASA was performed in 21 patients (65 ± 8.3 yrs) and validated by tomographic 3-D magnet resonance image reconstruction (3-DMR). Dynamic 3-DE data sets were obtained by ECG and respiratory triggering (Echoscan/TomTec). Image acquisition was performed from a transthoracic apical view using a rotational motor device. ASA and TESA were calculated enddiastolicly (TESA-ED; ASA-ED [cm^2]) and endsystolicly (TESA-ES; ASA-ES [cm^2]). Therefore, ASA and TESA were obtained from tomographic cross-sectional slices by manual planimetry of the endocardial contour of the aneurysm and the complete endocardial contour. Areas were calculated from contour length and slice thickness (3 mm) using the disc method. *Results:*

	ASA-ED	ASA-ES	TESA-ED	TESA-ES
3-DE	23.5 ± 13.4	23.2 ± 13.8	143.2 ± 35.2	115.4 ± 37.1
Mean of Diff.	3.3	2.9	5.2	3.8
SD of Diff.	5.6	5.4	6.9	7.2

Diff. = 3-DE – 3-DMR

A good agreement between the results of 3-DE and 3-DMR was found. As mean size of ASA related to TESA we found 19.4 ± 10.8% endsystolicly and 16.3 ± 8.9% enddiastolicly. Absolute size of ASA was constant during left ventricular contraction.

Conclusions: Left ventricular ASA and TESA can be quantified accurately by dynamic 3-DE. Therefore, dynamic 3-DE may be the most appropriate method to quantify other dysfunctional areas, in particular infarct areas.

939-118 Do Alterations in Load and Cardiac Output Affect Regional Shape and Global Geometry of a Normal Left Ventricle? A Quantitative Echocardiographic Shape Analysis Study

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Ventricular cavity geometry is an important determinant of LV function. It is not known whether LV shape is influenced by loading conditions. Regional curvature (C) and Fourier analysis (FA) yield indices of regional and global LV shape. In 9 dogs we examined the effects of saline infusion (SL) and nitroprusside (NP) on regional and global LV geometry. Apical long-axis 2-D echo was done at baseline and after each intervention. Regional C of the septum (S), apex (A) and posterior wall (P), and Fourier Shape Power Index (FSPI) were measured in end-diastole (ED) and end-systole (ES). *Results:*

With SL infusion, mean RA pressure and cardiac output (CO) rose 32% and 22%, respectively. Mean arterial pressure fell by 27% with NP with little CO change. Data on C and FSPI (Mean ± SEM) were:

	EDC-S	EDC-A	EDC-P	ESC-S	ESC-A	ESC-P	ED-FSPI	ES-FSPI
BSL	6.8 ± 1	23 ± 2	−1.1 ± 1	5.5 ± 1	30 ± 3	−1.0 ± 1	20.3 ± 2	41.7 ± 4
SL	7.1 ± 1	25 ± 2	−2.2 ± 1	8.1 ± 2	23 ± 1	−1.7 ± 2	19.6 ± 2	35.8 ± 4
NP	8.4 ± 1	21 ± 2	−1.1 ± 1	5.4 ± 1	31 ± 1	−1.4 ± 2	15.6 ± 2	36.1 ± 3

% Δ in FSPI was 115 ± 28, 96 ± 30 and 145 ± 21, respectively.

(BSL = Basal; There were no significant changes in the values between experimental states). Thus end-diastolic and end-systolic C, and FSPI and % ΔFSPI were relatively unchanged despite alterations in preload and afterload. *Conclusion:* Regional and global geometry of a normal left ventricle is relatively uninfluenced by acute changes in loading conditions and CO, and LV appears to retain its shape to maintain its functional capacity.

939-119 Improved Diagnostic Method for Detecting Left Ventricular Apical Injury

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During isovolumic relaxation (IVR) regional differences in myocardial function may alter intraventricular blood flow. A new digital echocardiograph allows 2-D color Doppler flow imaging of low velocities at high frame rates, thus improving the ability to study intraventricular velocities. We used this instrument for studying IVR in patients with myocardial infarction (MI).

Methods: 16 patients with angiographically proven apical MI, 10 patients with inferior MI and 10 healthy volunteers were studied. Cineloops were digital recorded from the three standard apical positions and stored for frame by frame studies during IVR. We achieved images at mean 33 frames per sec.

Results: During IVR, 15 of 16 patients with apical MI had blue-encoded flow directed from apex to the basis confined in the apical 2/3 of left ventricle (LV). Mean area of this color flow was 7.8 cm^2 (± 5.2 cm^2) and mean velocity was 9.7 cm/s (± 4.7 cm/s). This basis directed flow was not detected in any of the inferior MI patients or normal subjects. When flow was found, (9/10 of inferior MI patients and 8/10 of normals), it was always directed towards apex being red-encoded. Color M-mode with the beam placed through the mitral tips or aorta valves confirmed these findings of flow direction. A clearly blue-encoded signal was seen during IVR in patients with apical dyskinesia. The mechanism for the reversed IVR flow in apical dyskinesia is probably delayed contraction of the apical area.

Conclusions: Intraventricular flow during IVR is successfully visualized by new generation ultrasonic technology. Abnormal flow direction towards basal parts of LV strongly indicates apical injury of the myocardium.

939-120 Correlation of Scar Thickness to Myocardial Viability in Patients with Healed Myocardial Infarction

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Experimental study documented that reperfused scar is thicker than non-reperfused scar and it tolerates the infarct expansion. We hypothesized that viable myocardium exists in the outer layer of thick reperfused scar and its intrinsic contraction attenuates the expansion. We assessed the correlation of cardiac cycle-dependent variation (CV) of integrated backscatter (IB), that reflects intrinsic contractile performance, of inner and outer layers to the scar thickness in 13 patients with myocardial infarction (MI). We recorded magnified short-axis IB images with Acoustic Densitometry. We placed ROI in the inner and outer layers of akinetic segments to measure magnitude of CV (dB). When CV showed synchronous and asynchronous patterns, we expressed the magnitude as positive and negative value (corrected magnitude), respectively. Patients were divided into two groups based on scar thickeness: Gr-A (n = 9), ≤ 9 mm and Gr-B (n = 4), > 9 mm.

	Gr-A (n = 9)	Gr-B (n = 4)
Outer layer	-4.2 ± 3.0 dB (90%)	2.0 ± 0.4 dB* (0%)
Inner layer	-4.3 ± 1.5 dB (100%)	−0.7 ± 2.9 dB* (50%)

*P < 0.05 vs Gr-A, ( ): % asynchrony

The majority of Gr-A showed asynchronous contraction in both inner and outer layers, but all of Gr-B showed synchronous in the outer layer. Thus, there may be viable myocardium especially in outer layer of the thick scar. Intrinsic contraction of the outer layer may have a role to restraint passive stretching of infarct segment in patients with OMI.

939-121 Accuracy of Color Kinesis Technique for Quantitative Evaluation of Regional Wall Motion During Dobutamine Stress Test

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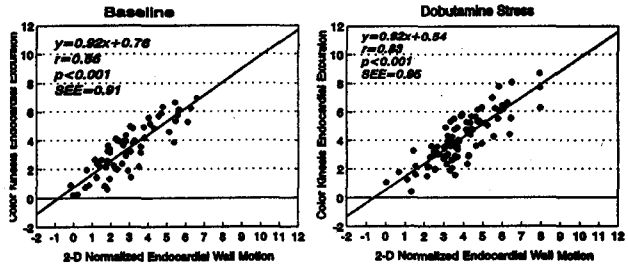
Color kinesis with a color encoded endocardial motion map may provide quantitative wall motion data during dobutamine stress echo (DSE), but the accuracy of this technique in stress conditions with tachycardia, exaggerated cardiac rotation and translation has not been tested. This study evaluated the accuracy of this system in 25 stages of regional LV dysfunction resulting from an LAD stenosis in 3 pigs during DSE. 2-D and color kinesis images were recorded at the mid-papillary muscle level. Sonomicrometers were implanted in mid anterior and inferior LV walls. The area of systolic endocardial excursion on the color kinesis map was digitized, analyzed by a modified centerline method and divided into 8 regions. 2-D LV endocardial borders were traced and analysed with a centerline method. *Results:* Regional endocardial excursion on the color kinesis map correlated well with regional wall motion on 2-D echocardiograms, both at baseline and during DSE (Figures). A good correlation was also seen between was sonomicrometers and color kinesis (r = 0 91, p < 0.01).



Conclusions: The color kinesis endocardial excursion mapping technique accurately quantifies regional wall motion. This new tool may lead to automation of wall motion quantification during DSE.

940 Nuclear Cardiology: New Approaches

Monday, March 17, 1997, Noon–2:00 p.m.
Anaheim Convention Center, Hall E
Presentation Hour: Noon–1:00 p.m.

940-97 Prediction of Outcome After Cardiac Transplantation Using Exercise SPECT Perfusion Imaging

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This study examined the prognostic value of exercise SPECT perfusion imaging in 71 patients performed after cardiac transplantation. There were 61 men and 10 women with a mean age of 53 ± 10 years. The mean exercise heart rate was 127 ± 22 bpm and exercise work load 6 ± 3 METS. During a mean follow-up of 26 ± 17 months, there were 6 cardiac events (3 deaths and 3 nonfatal myocardial infarctions). There were 3 events amongst the 7 patients with abnormal SPECT and 3 events amongst the 64 pts with normal SPECT (P < 0.001). The Kaplan Meier event-free survival was significantly better in patients with normal than abnormal SPECT (95% vs 57%, P < 0.0001). The annual event rate was 2% in patients with normal SPECT and 20% in patients with abnormal SPECT (P < 0.001).

Thus, stress SPECT perfusion imaging is useful in predicting outcome after cardiac transplantation. Events are infrequent in patients with normal images, but the progressive nature of coronary arteriopathy in some patients necessitates serial testing.

940-98 Comparison of the Prognostic Value of MIBG Uptake and Peak Exercise Oxygen Uptake in Chronic Heart Failure

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Decreased cardiac meta-iodo benzyl guanidine (MIBG) uptake has been

MONDAY POSTER